FACT SHEET

U.S. Department of Energy
Grand Junction Office

Pinellas Environmental Restoration Project: Remediation of NAPL-Contaminated Groundwater at the Northeast Site at the Young-Rainey STAR Center, Largo, Florida

The U.S. Department of Energy (DOE) has implemented innovative technologies to remediate contaminated groundwater at the Northeast Site at the Young-Rainey Science, Technology, and Research (STAR) Center. Remediation is being conducted using steam injection and electrical heating to heat the subsurface. The heating vaporizes the contaminants that are then removed from the subsurface through extraction wells, followed by treatment at the ground surface. This cleanup is being conducted as part of the Pinellas Environmental Restoration Project that is managed by the DOE Grand Junction Office.

Background

The Young-Rainey Science, Technology, and Research (STAR) Center is a former U.S. Department of Energy (DOE) facility located in Largo, Florida. Parts of the site are contaminated with organic solvents and metals used during the manufacture of neutron generators and other devices. In keeping with DOE's desire to contribute to economic development in the Tampa Bay region, DOE sold the facility to the Pinellas County Industrial Council on March 17, 1995. The sales contract includes clauses to ensure continued compliance with federal, state, and local regulations while DOE conducts remediation at the site.

In 1999, the Pinellas County Industrial Council was disestablished and ownership of the STAR Center changed to the Pinellas County government. The facility houses more than 20 businesses that range from administrative to light manufacturing. The Northeast Site is located at the northeast corner of the STAR Center (Figure 1).

As a result of historic waste disposal practices, contamination exists in the subsurface. The contaminated areas are designated as solid waste management units. Four units at the STAR Center have contamination in the surficial aquifer groundwater at levels in excess of protective standards and are undergoing remediation. The Northeast Site is one of the solid waste management units that requires remediation. Parts of this area were used for disposal of drums of solvent waste in the 1950s and 1960s. Over time, the drums leaked this waste into the subsurface.

The spilled solvent penetrated through the soil until it reached the groundwater. As the solvent contacted the groundwater, it started to dissolve into (mix with) the groundwater. For many solvents there is a limit, called the solubility, to the amount of solvent that will mix with the groundwater. Once this limit is reached, no more solvent will mix with the groundwater. At that point, the solvent will remain in the ground as a separate phase that is not mixed with the water, leading to a non-aqueous (not water) phase liquid. Therefore, this type of contamination is called a non-aqueous phase liquid (NAPL).

NAPL solubility can be illustrated by visualizing pouring a liquid such as cooking oil into a glass of water. The oil does not mix with the water, but remains as a separate phase, a non-aqueous phase liquid. Figure 2 shows a groundwater sample collected at the Northeast Site that contains two kinds of NAPLs: a dense non-aqueous phase liquid (DNAPL) and a light non-aqueous phase liquid (LNAPL).

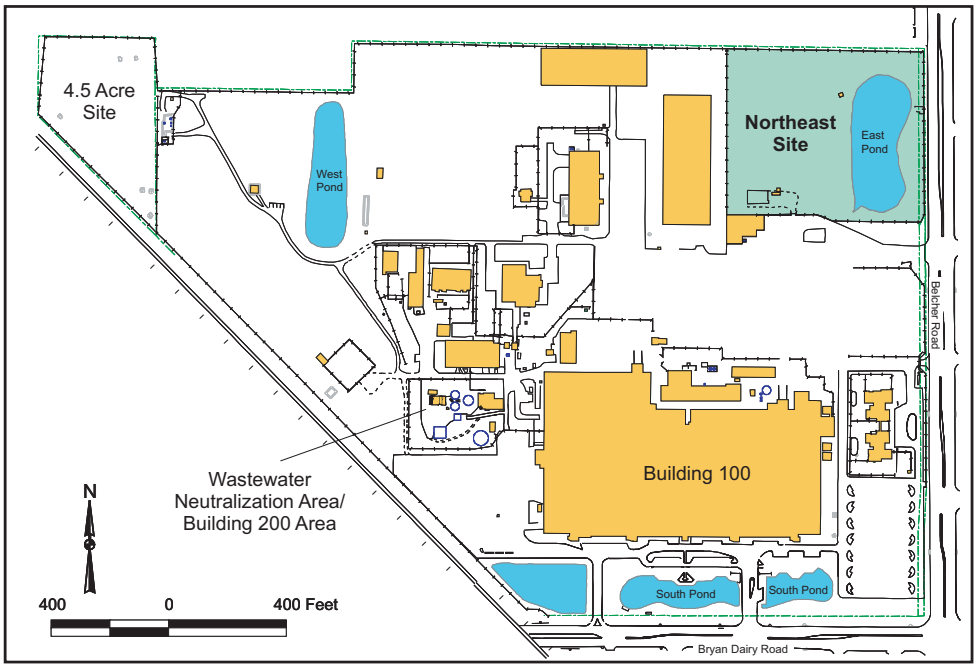

Figure 1. Location of Northeast Site

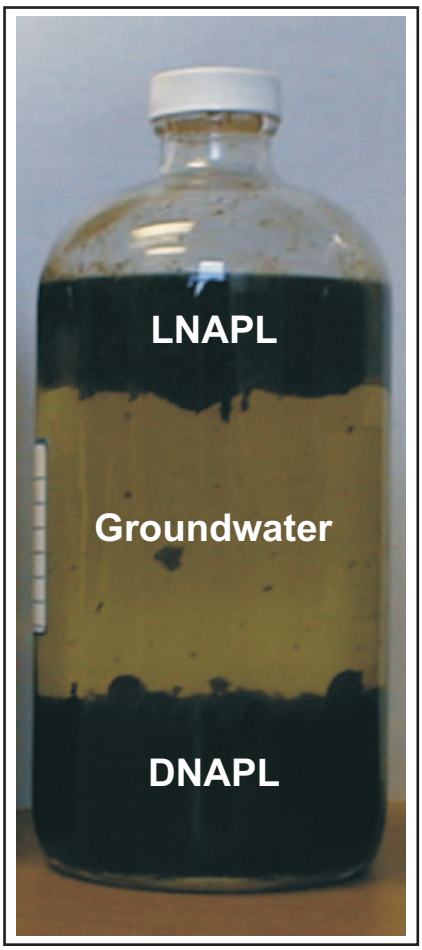

Figure 2. Groundwater sample collected at the Northeast Site

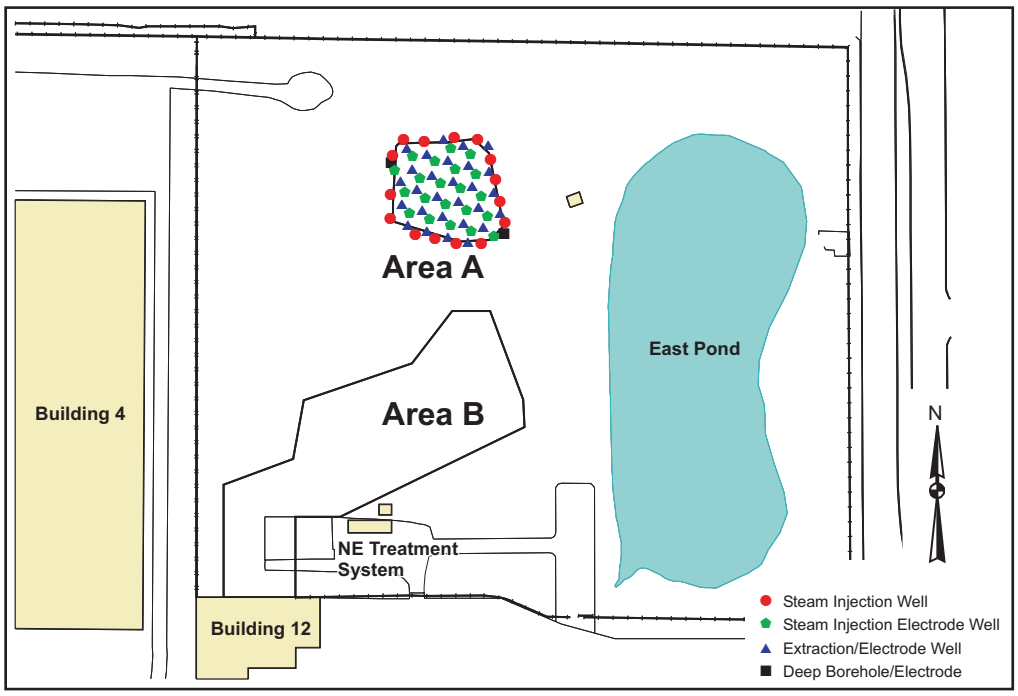

Figure 3. NAPL remediation areas and treatment wells at Northeast Site

As the groundwater moves away from the NAPL-contaminated area, clean water will flow past the NAPL and more of the NAPL will mix with the clean water. Though all the NAPL will eventually mix with the groundwater, this process may take decades or even centuries because of the limited solubility of the NAPL.

The amount of time for all the NAPL to mix with the groundwater depends on the chemical composition of the NAPL, the amount of the NAPL in the subsurface, and the speed at which the groundwater flows past the NAPL-contaminated area. The NAPL acts as a continuous source of groundwater contamination until the mixing process is complete.

Efforts to clean the contaminated groundwater, such as pumping the water from the subsurface to the surface for treatment, may have little effect on reducing the contamination because the NAPL continues to mix with groundwater as the water is pumped. The NAPL must be removed before the groundwater can be cleaned up.

Some of the NAPL contaminants at the Northeast Site are dichloroethene, methylene chloride, trichloroethene, and toluene. Oil is also present as a NAPL. Because of DOE's desire to expedite cleanup of this site, innovative methods for remediation of groundwater and soils are being implemented.

NAPL Remediation

After evaluating the different methods available for treating NAPLs at the Northeast Site, DOE selected steam injection and electrical heating. The NAPL remediation will be conducted in two phases. The first phase consists of using both technologies to treat the smaller NAPL Area A (Figure 3) in the northern part of the Northeast Site. If the technologies prove effective at treating this small area, they will be used in Area B during the second phase. Active treatment in Area A was completed in February. Confirmatory sampling will be conducted to determine if it was successful. The remediation has been carefully planned to ensure that contamination does not migrate outside the treatment area. Electrical heating and steam injection will provide rapid and effective remediation of the Northeast Site with no adverse long-term effects.

Steam Injection

Steam is created in a boiler and then injected into the subsurface through injection wells. The steam travels through the subsurface, heating the soil, the groundwater, and the NAPLs. As the temperatures of the NAPLs rise, the NAPLs are converted to vapors. These vapors are then extracted from the subsurface through extraction wells. These extraction wells will also remove contaminant vapors, water vapor, liquid water, and liquid NAPL.

Steam is injected in wells around the perimeter of the area, creating a steam donut that prevents contaminants from moving laterally outside the treatment area.

Figure 4. Injection and extraction wells in Area A

The steam drives the NAPLs and the groundwater toward the center of the donut and the extraction wells. Then steam is injected in wells inside the treatment area, further heating the subsurface and sweeping the contaminants toward the extraction wells. After the treatment zone is heated to its maximum temperature and the bulk of the NAPLs are recovered, the subsurface is surged by inducing pressure changes. Pressure changes are achieved by varying the steam pressure, the electrical heating rate, and the amount of vacuum applied by the recovery system. Figure 3 shows the locations of the injection and extraction wells in Area A, Figure 4 presents a ground surface view of the wells, and Figure 5 shows the NAPL treatment system at the Northeast Site.

Electrical Heating

Electrical heating is accomplished by inserting electrodes into the subsurface. Electrical current is fed to these electrodes, and the current is conducted through the soil between the electrodes. As the current passes through the soil, the soil is heated due to the electrical resistance of the soil. This same principle causes an electric heater to produce heat. Electrical heating produces the same effect as steam injection, in that the NAPLs are converted to vapors that are then removed through the extraction wells.

Electrical heating is used initially to create a "hot floor" beneath the NAPL area to prevent contaminants from migrating downward. When combined with the perimeter steam injection wells, the hot floor helps ensure containment of the contaminants within the remediation area. Electrical heating is used to treat potential "cold spots" not reached by the injected steam. Figure 3 presents locations of the electrical heating electrodes.

Electrical heating and steam injection work well in combination because these technologies compensate for each other's weaknesses. Steam tends to move through and heat subsurface areas that have higher permeability, potentially leaving areas with lower permeability at a cooler temperature. Electrical heating tends to treat the lower permeability areas because these areas more readily conduct current. When used together, these two technologies offer a more efficient remediation than a single technology.

Extraction Wells

While the NAPL area is being heated, water is pumped from the extraction wells (see Figure 3). The extraction wells are fitted with high-pressure vacuum systems to collect vapors. The combined extraction rate exceeds the steam injection rate by 25 percent, which means more water is removed from the treatment area relative to the groundwater that flows into it. As contaminants are pushed in and up by the heating, they are aggressively captured by the extraction wells. An asphalt cap over the treatment area prevents vapors from escaping and diverts storm water. The extraction system extends 30 feet outside the treatment area to prevent vapors from escaping.

Figure 5. NAPL treatment system at the Northeast Site

In Situ Subsurface Monitoring

The progress of the remediation is monitored with a network of instruments that measure temperature and electrical resistance in the subsurface. These measurements are evaluated to ensure that all subsurface areas are heated and to slow heating in areas that appear to have completed remediation.

Contaminant Treatment

The extracted liquids and vapors are carried to the treatment system (Figure 5) by surface pipes where they are cooled; some contaminant vapors are condensed back to the liquid form. Other contaminants that remain as vapors are treated by passing them through activated charcoal. The recovered NAPLs are disposed of by a hazardous waste disposal contractor. The cleaned air is vented to the atmosphere, and the cleaned water is sent to the STAR Center Wastewater Treatment Facility.

Remediation Goals

Table 1 presents the cleanup goals for the Northeast Site. With the completion of active treatment in Area A, confirmatory sampling is beginning. Sampling of groundwater and soil will be conducted after active treatment ends at 4, 12, and 24 weeks as the subsurface cools down. The treatment will be considered a success if the remediation goals are achieved at 24 weeks after shutdown.

Table 1. Cleanup goals for Northeast Site

NAPL Component	Groundwater Cleanup Goals (micrograms per liter)	Soil Cleanup Goals (micrograms per kilogram)
Trichloroethene	11,000	20,400
cis-1,2-Dichlorethene	50,000	71,000
Methylene chloride	20,000	227,000
Toluene	5,500	15,000
Total petroleum hydrocarbons (oils)	50,000	2,500,000

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Additional information and fact sheets about the Pinellas Environmental Restoration Project at the Young-Rainey STAR Center are available on the Internet at **http://www.gjo.doe.gov/Pinellas/index.htm.**